II.—THE MEDULLA OBLONGATA.

I. KRANKHEITEN DES VERLAENGERTEN MARKS. Pp. 831–960. *Handbuch der Krankheiten des Nervensystems*, Bd. II., zweite Haelfte. Von Dr. Wilhelm Erb. Zweite Auflage, 1878. (*Diseases of the Medulla Oblongata, &c.*)

II. MOELLE ALLONGÉE OU BULBE RACHIDIEN. *Dict. Encyclopedique des Sci. Med.*, deuxieme serie, tome huitieme. Premiere partie. Pp. 301–328. Du meme, deuxieme partie. Pp. 604–788. (*The Medulla Oblongata, or Rachidian Bulb.*)

No part of the central nervous system has more seriously challenged the attention of the anatomist and physiologist, or more thoroughly baffled both, than the medulla and the pons, with which latter the medulla sustains such close relations. So unfruitful do the elaborate anatomical investigations of this part of the cerebro-spinal axis appear to some judicious observers, as to lead one of the foremost among them to declare during the past year, in the important work cited at the head of this notice, that "the anatomy of the medulla oblongata is yet in many and perhaps the most important relations, imperfectly or not at all known. "The relations are extraordinarily difficult to unravel. The connections of the structures of the medulla oblongata with the recognized structures of the spinal cord, and with the sections of the nervous system lying above it on the other hand, are on the whole extraordinarily complex, manifold, intricate, and in spite of the most extreme care in anatomical investigation, are yet in great measure in darkness. It is hence easily enough to be explained, that the views of the best observers, concerning the minute structure of the medulla oblongata, are yet in many points widely asunder." So much for the present state of the anatomy of the medulla. As regards the *physiology* of the medulla, the same conservative and cautious observer (Erb), speaks as follows: "Not less imperfect and doubtful than the anatomy of the medulla oblongata is its physiology. As regards the more intimate and important questions of its physiology there has not been obtained as yet any indisputable knowledge." And such in most instances is the sum of the testimony of the best observers.

And yet perhaps, not another part of the central nervous system has been the object of more elaborate investigations.

It has been most carefully studied by such anatomists as Koelliker, Stilling (especially the latter), Clarke, Schroeder Van der Kolk, Deiters, Meynert, Luys, Dean, Henle, Sappey and Duval, Gerlach, Huguenin, Stieda, Faraboeuf, Flechsig and a host of others. And yet after all, we have the judgment above uttered by Dr. Erb, from which it would appear that but little substantial progress has been made.

This is unhappily too true. But it seems to us the statements quoted above underrate our real knowledge of this part of the nervous system. A comprehensive survey of our present knowledge of the anatomy, physiology, and pathology of the medulla, we believe will warrant us in going farther than does Dr. Erb. It is our purpose in this article to briefly state what we believe to be established, and what probable in regard to the structure and functions of the medulla.

It may be laid down as a cardinal principle for guidance in a study of the nervous system, that our knowledge of its structure and functions, derived from a study of its simpler parts, is to be applied industriously in the study and interpretation of more complex parts. These latter parts differ chiefly from the former in their degrees of complexity, rather than in *kind* of structure and function. In applying this simple and well known rule in a study of the medulla, we should rise from a study of the spinal cord, which is simpler and better understood, carrying up the results to the medulla, which, whatever else it may have or do besides, contains the same anatomical elements and discharges similar functions to the cord. The sensory or esthesodic, and the motor or kinesodic tracts, both grey and white of the cord, are continued upward through the medulla, though changed in their form and relations. To these many new parts or what seem to be such, are added, by which at least its size is augmented. As compared with the cord the medulla is considerably changed in form, as already said, partly by changes of relative position of masses of matter, and partly by special additions of grey matter and fibres, which increase its size but which are peculiar to the medulla in appearance rather than in fact. The same principles of interpretation of structure and function which apply to the cord apply to the medulla. It presents but little if anything radically new as compared with the cord below it. But it is more complex. If these remarks are true, it is necessary for us to state in the outset of a study of the medulla, what are the more important of our items of knowledge of the structure and functions of the spinal cord. This we shall accordingly do.

There is one point in the nervous system only in which there is seemingly a complete *anatomical* separation of its sensory and motor tracts, viz.: just before the nerves plunge into the cord and medulla. Ever since their discovery by Sir Charles Bell, it has been known of the two roots of the mixed nerves, that the posterior is sensory and the anterior motor. Outwardly from this point, the fibres of these two bundles as a rule mix, and yet are known to preserve their characteristics and to go to their destinations in the muscles, glands, &c., and to the sensory surfaces, as certainly as if they had remained distinct in space relations in their whole course, as they are before entering the cord. The esthesodic and kinesodic tracts are distinct, and known to be so, in spite of appearances, from the separated roots of the spinal nerves, outward to the periphery of the nervous system. On the other hand, after the disappearance of the bundles of fibres composing the sensory root into the posterior aspect of the spinal cord, and of those composing the anterior or motor root, into the anterior aspect of the cord, we lose sight of them, and the most penetrating anatomical investigation has not been able thus far to follow them to any considerable distance, so as to tell by such means what course they actually take in the cord, in any considerable numbers. And so far as we can judge from present appearances, it will always be difficult if not impossible to follow anatomically, the fibres of the cord to any considerable distance, unless by indirect methods, such as those adopted by Flechsig in carrying out his remarkable researches. But this much may be said with considerable certainty, that every advance in our knowledge goes to render more probable the assumption, that however intimate may be the relations of the motor and sensory tracts in the cord for reflex purposes, they are yet not less distinct in other respects than are these two tracts in the roots of the spinal nerves. They pursue a parallel but a definite and distinct course upwards into the brain, in all probability. This general statement being admitted, as we think it must be, we are prepared for further general statements as regards the cord as a whole. There is every reason to suppose that the fibres of the motor and sensory roots of the nerves when they enter the cord, terminate sooner or later wholly in its grey matter. There is no good reason whatever for supposing that any fibres from either root passes without interruption up to the brain. They all probably enter the grey matter of the cord.

Confining our attention, now, to the fibres of the posterior or sensory root, and admitting that they enter and terminate directly or indirectly in the cells of the grey matter, we may go farther and state that they do so apparently for two general purposes, and two only, viz.: for immediate reflex purposes, and that sense impressions may be conveyed upwards to the brain, where they may be manifested in consciousness. There must then quite plainly be, two classes of mechanisms in the cord to subserve these purposes, however powerless the anatomist may be to make a clear demonstration of them. One is to convey sense impressions entering the cord to corresponding motor mechanisms on the same level, and in the same side of the cord, or to a higher level in the same for reflex purposes, the other to convey impressions up to the brain.

To convey nervous impulses upwards toward the brain, there must be some provision, such as is known to exist in other parts of the nervous system for similar purposes. This is usually nerve fibres, and there is every reason for believing that this is true for the spinal cord. The *routes of preference* for such impressions, are, in all probability, chiefly in the bands of fibres in the lateral columns of the cord. Yet it is necessary to admit that such *may* be conveyed upwards in its grey matter, in most if not all its parts. That sensory fibres emerge from each segment (corresponding to pairs of nerves) of the grey matter of the cord and medulla, and that these pass upwards to terminate in the grey matter of the basal system of ganglia, or pass through the internal capsule upwards to the grey matter of the cortex of the brain proper, there can now be little queston. These fibres may, some of them, pass upwards in the posterior columns as Schiff supposes (though we think this is doubtful), but that they pass mostly in the mass of the lateral columns, seems tolerably certain. That they take their origin in the grey matter of one side of the cord, cross the middle line, and ascend toward the brain in the opposite half of the cord, seems highly probable.

Then, again, it is pretty well established that fibres arise from the cells of the grey matter of the cortex of the brain (motor zone), and that from thence they pass downwards to the level of the basal system where some of them terminate, while others pass by the basal system through the internal capsule to terminate,after crossing chiefly over the middle line, in the grey matter of the medulla and cord, so as to connect by this means various horizons of the grey matter of the cord and medulla, with particular regions of the cortex, while other fibres connect the grey matter of the basal system with various horizons of the grey matter of the medulla and cord, for automatic rather than voluntary purposes. That these fibres of both kinds (motor) are contained chiefly in the lateral columns of the cord, and probably also in the columns of Tuerck of the anterior columns, and that they terminate in the cells of the kinesodic tract, so as to excite the motor apparatuses, from which the motor roots of the spinal and medullary (cranial) nerves arise, seems quite probable from every point of view.

We thus have in the cord, provision for reflex action and for the transmission upwards towards the brain of sensory impulses, and on the contrary downward from the brain of motor impulses, and we seem now in position to lay down what are the mechanisms for such actions, and to no inconsiderable extent, their topographical relations in the cord. The anterior horns of grey matter are undoubtedly motor, while the posterior ones are no doubt chiefly sensory.

Now, the point in all this is, that what is true for the cord is also true for the medulla. If we have any certain knowledge of the former, to that extent we have a certain knowledge of the latter. The same tracts of matter which exist in the cord are found continued up into and through the medulla, to the grey matter of the ganglia of the basal system and cortex of the brain, including no doubt that of the cerebellum.

It is now known with a fair degree of certainty that the anterior pyramids of the medulla are largely composed of bands of fibres derived from the lateral column of the opposite half of the cord (crossed pyramidal tract), and from the anterior column of the cord of the same side (column of Tuerck—direct pyramidal tract). It is also known that the fundamental tracts of the anterior columns of the cord, as they approach the medulla, are pushed outwards so as to pass beneath, and then outward from and behind the olivary bodies, and then ascending behind the pyramids they approach the raphe, decussate probably and ascend toward the opto-striate body. It is known also that the lateral columns of the cord, as they pass upwards to the level of the medulla, are probably disposed of as follows: A tract of motor fibres, already mentioned, which crosses over from one side to the other at the pyramidal crossing, so as to join the opposite anterior pyramid of the medulla. A tract of sensory fibres which enters the lateral part of the medulla and bends toward the raphe and ascends through the tegmentum of the crus, partly to the cells of the optic thalami, and partly through the posterior part of the inner capsule to the cortex of the hemispheres. That another tract of the lateral columns, embraced in its posterior third, passes upwards, enters the corresponding restiform body, and reaches thus the cerebellum of the same side. That the anterior one-half of the bundle of fibres of the lateral column (anterior mixed tract) passes upwards to the level of the medulla, appearing to terminate in its lateral part at the reticular formation, where some fibres seem to terminate in cells, but the major portion cross the raphe and ascend behind the pyramids to the striate body (nucleus lenticularis and nucleus caudatus). That in all probability these lateral columns contain secretory, vaso-motor, and other fibres, which are continued doubtless into the medulla. That the fundamental portion of the posterior columns of the cord (columns of Burdach) pass upwards, and largely bending beneath the floor of the fourth ventricle, ascend, and as they do so approach the raphe, decussate for some distance up the raphe, and then taking a position behind the representative in the medulla of the corresponding part of the anterior column of the cord, they pass to terminate chiefly in the thalamus opticus. Then again as regards the grey matter, it is continued upward from the cord into the medulla, much modified in form and situation, but still clearly recognizable. The anterior horns of grey matter in the medulla are almost or quite severed from the central grey matter, and in this it differs from the cord. The anterior horn of grey matter, as it passes up through the medulla, is pushed backwards with the fundamental portion of the anterior white column which belongs with it, and it is more divided into separate portions than in the cord.

The posterior horns of grey matter are also cut off in great measure from the central grey matter, and divided into separate nuclei more or less clearly, and the whole posterior cornu of the medulla is carried outward and forwards, so as to occupy relatively in the medulla a very different position from what it does in the cord. Then the central grey matter which forms a tube in the cord, is in the medulla laid open from behind down to the central canal, and then spread out laterally so as to expose the central grey matter in the floor of the fourth ventricle on the back of the medulla. This laying open the grey tube down to the central canal, in that part of its course which corresponds to the medulla, and the rolling outwards of the divided edges, it will be readily seen, would impose certain changes in form of the medulla as compared with the cord, and certain changes in relative position of parts, which are found by actual investigation to be much as might have been expected *a priori.* By such an arrangement as we have adverted to, it would be expected that the medulla, as compared with the cord, would be wide from side to side, and thin antero-posteriorly. This is seen at once to be the fact.

The medulla has various nerves enter and implant their fibres in its cell groups, but this also happens to the cord, but in a less orderly manner in the former than the latter. The nuclei of the motor and sensory nerves of the medulla, are more distinct than those of the cord. But they are destined to act with more independence and in more complex relations than those of the cord, and hence their comparative distinctness. Then, again, the medulla contains vaso-motor, cardiac, respiratory, secretory and other important centres, especially situated in or near the floor of the fourth ventricle. But the medulla above the cord, as it is in rank in all physiological aspects, is not in much peculiar even here as compared with the cord. The cord also contains vaso- motor, secretory, respiratory centres, &c., though subordinate to those in the medulla. Then again, the medulla as compared with the cord has some special formations, such as the olivary bodies, by which its size and complexity are increased.

But the anatomical and physiological relations of these bodies (olivary) are too imperfectly understood as yet, to enable us to say to what extent they impose differences on the medulla, as compared with the cord. The olivary bodies are certainly very special structures and this points to their having very special functions. But we may recur to these bodies briefly again. Then, the medulla as compared with the cord, is provided with a very great number of commissural fibres, which implies what is known to be a fact, that the actions excited from the medulla are bilateral as a rule. But this state of things is not peculiar to the medulla, though far less true of the brain and cord. Its relations with the cerebellum especially, through the cerebellar fibres of the pons, are numerous and complex, but the cord also has relations with the cerebellum, especially through the restiform bodies, or portions of the same.

The special nuclei of the medulla, which so much abound, and the central massive portions of the grey matter of the medulla have very extensive and complicated relations with the cell groups above in the basal system and cortex of the cerebrum, but there is no reason to suppose they differ fundamentally from those believed to exist in the cord.

(*To be continued.*)